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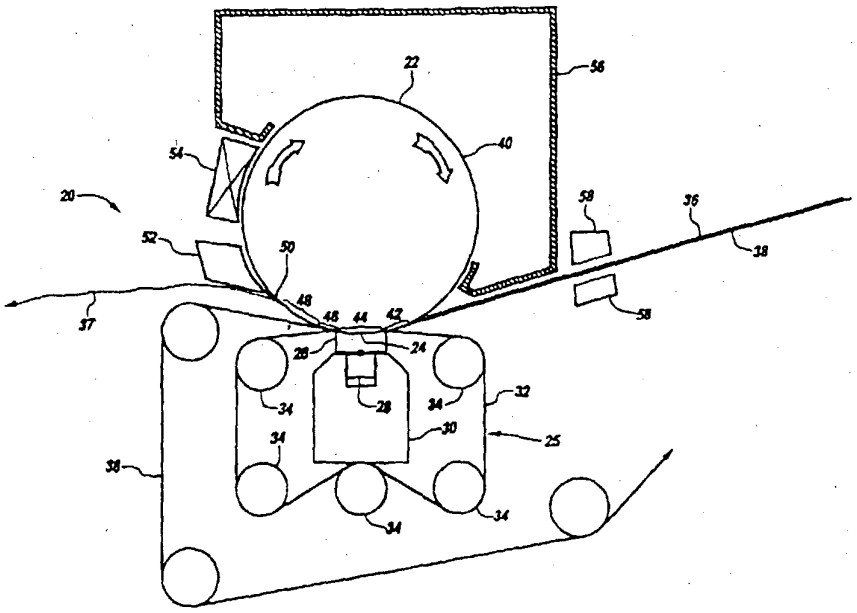

(57) Abstract

A tissue dryer has a dryer roll which is externally heated by induction to raise the roll surface temperature to between 300-700 °F while allowing internal hydraulic crown support of the roll. The hydraulic support of the roll exerts pressures of between 1 000-10 000 pounds per linear inch. The drying performance of the dryer is enhanced by providing a prewarp of the web onto the hot roll just before the pressing nip. After the web transits the nip it is removed by a doctor blade which crepes the web. The web is fully restrained during the majority of the drying process thus requiring no adhesive sprays.

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TITLE:
TISSUE IMPULSE DRYER

FIELD OF THE INVENTION

The present invention relates to the pressing and drying sections of papermaking machines in general and to dryers for tissue in particular.

BACKGROUND OF THE INVENTION

Tissue papers, generally including the papers used to form facial tissue, toilet paper and paper towels, are manufactured from a grade of paper which is, in contrast to ordinary paper, designed to be soft, of high bulk, and absorptive.

Tissue paper is normally manufactured by applying a thin web of paper pulp onto the surface of a so-called Yankee dryer. The Yankee dryer is a single large diameter steam heated roll, typically 12-22 feet in diameter. The wet web is pressed directly onto the cylindrical Yankee dryer roll by one or two pressure rolls. These rolls act to remove some of the water from the sheet and cause the web to adhere to the Yankee roll. Special sprays are sometimes used to enhance the adhesion of the web to the Yankee roll. The drying rates are generally augmented by using high-velocity, hot-air impingement hoods. After drying, the web is scraped off the Yankee roll by a doctor blade. This doctor tends to break fiber-fiber bonds and to produce a creped surface in the web. This action gives the web the properties of softness and stretch.

Conventional Yankee dryer rolls, which have steam pressures of up to 160 psi, achieve surface temperatures approximately 185° F. Because of the need to contain the steam pressure, a Yankee dryer roll requires thick walls. These thick walls result in a large temperature drop between the steam heated interior and the outer surface of the dryer roll. Furthermore, with a Yankee dryer roll, the pressing load is generally limited to about 500 pli (pounds per inch of roll width).

One of the problems with the conventional drying process is that the web must be dried on only a single Yankee roll for highest quality because the web must be dry by the time it is creped from the Yankee roll. Since only one Yankee roll is used, there is a natural limitation to the amount of drying that can be achieved on the roll and hence, the rate of production of tissue using a Yankee dryer is limited.

A second problem is that the loading of the pressure rolls is limited by stresses in the shell of the Yankee dryer. Although it is possible to make the shell of the Yankee dryer stronger by increasing its thickness, it is difficult to cast thick shells and any increase in shell thickness will increase the thermal resistance of the shell and reduce the drying capability of the Yankee dryer still further.

A third problem is the need for adhesive sprays. These sprays are costly and are difficult to apply consistently.

Yet another problem is the size of the Yankee dryer roll. The desire to increase productivity of the Yankee dryer has led to dryer rolls of larger and larger size until currently they are being built 18 to 22 feet in diameter. Further increasing the diameter of the Yankee dryer has practical difficulties. The current diameters are close to the practical limit for shipping large cylinders between the manufacturing site and the paper mills. In addition, as the diameter of the cylinder is increased, the wall thickness must be increased as well to withstand the internal steam pressure, this in turn increases the thermal resistance of the shell and reduces the drying capability.

Another difficulty associated with the conventional Yankee dryer system is the high cost. There are only a few specialized foundries in the world capable of casting the large cylinders. Further, the other components of the tissue machine employed with the Yankee dryer, such as the covered press suction rollers and the high-velocity hood and air system over the Yankee dryer are also very costly.

World Patent No. 93/23613 discloses using an extended nip press and a crown supported press roll for drying voluminous paper webs, destined in

particular for the production of toilet paper. The process disclosed in the World patent is directed to allowing tissue papers to be dried with smaller structural units. The process therein disclosed starts with an initial dry weight content of the web of between 10-30 percent absolute dry weight. The pressure in the extended nip is at least 10 bars which amounts to approximately 145 psi. The World patent device shows one possible method for heating a press roll by providing an induction heater to heat the roll. Said induction device generates localized heat that may be regulated in the metallic outer surface of the press roll. The World patent suggests at least one of the pressing surfaces in the pressing zone be heated to at least 238° F to approximately 508° F. The World patent further discloses a tissue web which is at least 60 percent to more than 80 percent dry after being hot pressed.

The World patent, on the other hand, teaches the application of an adhesive medium to the dryer roll in order to improve the adhesion of the web during the creping process. The World patent also does not teach how to get the dry weight of the tissue to greater than 90 percent such as produced by a typical Yankee dryer.

What is needed is an apparatus and method for drying tissue paper which does not require the large diameter Yankee dryer.

SUMMARY OF THE INVENTION

The tissue dryer of this invention employs a dryer roll which is externally heated by induction. The external induction heating not only raises the dryer's surface temperature to a range of 300-700° F, but also allows an internal hydraulic crown support system. The hydraulic support of the drying cylinder allows the employment of an extended nip press which exerts pressures of between 1,000-10,000 pounds per linear inch. The high extended nip pressure combined with the high surface temperature of the drying roll dries the web by a combination of temperature-enhanced pressing and flash drying. The drying performance of the dryer is also enhanced by providing a prewrap of the web onto the hot roll just before the pressing nip. After the web transits the nip, the web remains adhered to the dryer surface until removed by a doctor blade which produces the crepe or softness in the web. Special stationary pans are then used to convey the web away from the doctor and on to the subsequent

operations, such as calendering and winding onto a reel spool. The web is fully restrained during the majority of the drying process and because a significant portion of the drying occurs under pressure, the need for adhesive sprays and the common problem of sheet blistering or blowing off the roll surface may be avoided.

It is a feature of the present invention to provide a tissue-making machine which can operate at higher speeds.

It is another feature of the present invention to provide a tissue-making machine which can employ a dryer roll of smaller circumferential dimensions.

It is another feature of the present invention to provide a tissue-drying machine wherein the dryer roll does not require internal steam heating.

It is another feature of the present invention to provide a tissue dryer roll which can function without adhesive sprays for retaining the tissue web to the dryer surface.

It is a still further feature of the present invention to provide a tissue-making machine of lower overall cost.

It is a yet further feature of the present invention to provide a tissue-making machine in which there is no need for suction press rolls.

Further objects, features and advantages of the invention will be apparent from the following detailed description when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic cross-sectional view of the tissue dryer of this invention.

FIG. 2 is an alternative embodiment tissue dryer of this invention having a crown-supported dryer roll and an enclosed-loop blanket extended nip press.

FIG. 3 is an alternative embodiment of the tissue dryer of this invention in which the web is wrapped more than 180° around the circumference of the dryer roll.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring more particularly to FIGS. 1-3 wherein like numbers refer to similar parts, a tissue dryer 20 is shown in FIG. 1. The dryer 20 employs a cylindrical press roll 22 which forms an extended nip 24 with a shoe 26. The shoe 26 is supported by one or more hydraulic cylinders 28 which are supported on a beam 30. A grooved blanket 32 is supported on rollers 34 and passes through the nip 24 and around the shoe 26 and beam 30. Lubricating fluid is injected between the blanket 32 and the shoe 26 forming a hydrodynamic wedge which allows the belt to move freely through the nip 24. Thus, the blanket 32 is supported hydrodynamically against the roll 22 and pressures of 1,000-10,000 pounds per linear inch along the axis of the roll 22 can be applied by the hydraulic cylinder 28.

A tissue web 36 leaves a former (not shown) on top of a press felt or forming fabric 38 and is conveyed by the forming fabric 38 directly into the extended nip 24 of the impulse dryer 20. The web 36 and felt 38 are pressed against the hot surface 40 of the roll 22, bringing the web 36 into direct contact with the roll surface 40.

As shown in FIG. 1, the web 36 engages the surface 40 of the roll 22 slightly in front of the nip 24 so that the web 36 is preheated over a preheat wrap region 42. After the web 36 is preheated it enters a region 44 of high pressure pressing induced by the shoe 26 which forms the extended nip 24 with the roll 22. The shoe 26 is typically about ten inches long in the machine direction. The high pressure will be preferably be in the range of 1,000-10,000 pounds per linear inch along the cross-machine direction of the roll 22. The high pressure of the nip brings the web 36 into intimate contact with the roll surface 40 which greatly increases heat transfer. Drying then takes place by a combination of temperature-enhanced pressing and flash drying. The process by which drying takes place in the extended nip is not completely understood. However the process involves steam and water moving from the web into and through the forming fabric 38 and in turn into the grooves in the blanket 32. The grooves of the blanket 32 extend circumferentially about the extended nip 24 and thus allow steam and water to vent from the nip.

After the web 36 and the forming fabric 38 move through the pressing region 44 the web 36 is held against the surface 40 of the roll 22 forming a post-heating region 46. After the post-heating region 46 the forming fabric 38 is pulled away from the web 36, while the web remains adhered to the surface 40 of the roll 22, forming an unbacked drying region 48. The dry web 36 is then scraped from the roll surface 40 by a doctor blade 50 mounted to a doctor back 52. The doctor blade 50 removes the web 36 and at the same time produces the crepe and softness in the web which is the desired end result of the drying method employed. The doctor blade 50 will typically be located about forty-five degrees or more down stream of the nip 24.

Heat is supplied to the roll by an induction heater 54. The induction heater 54 is mounted as shown in FIG. 1 above the doctor back 52. Commercially available induction heating systems are capable of very high energy transfer rates and thus the use of induction heating greatly increases the drying capability of the impulse dryer 20 over a conventional Yankee dryer steam-heating system. An induction heater functions by inducing a electrical current in the surface of a conducting roll. The induced current can be very large and will thus produce resistive heating in the surface of the metal roll. As shown in FIG. 1, to prevent the heated roll from cooling as the surface of the roll moves from the induction heater 54 to the preheat region 42 a hood 56 is positioned between the induction heater 54 and a position adjacent to the preheat region 42. The hood prevents convective and radiative heat transfer away from the roll by insulating the roll's surface.

A steam shower 58 may be used to preheat the web 36. The steam shower 58 preheats the web before it is wrapped onto the surface 40 of the dryer roll 22. As the web 36 is wrapped onto the dryer roll 22 it will typically be 12-24 percent dry, more usually 16-18 percent dry. As the web leaves the dryer roll 22, after being removed by the creping doctor 50, the web will typically have a dry content of 92-95 percent. The web, as removed by the doctor, is still quite hot and a certain amount of flashing or evaporation of the remaining moisture increases the dry weight to 94-97 percent. At the same time flashing lowers the temperature of the web 36 so that the web enters a winder (not shown) with a sufficiently low temperature to be wound into a reel.

The dryer roll 22 is typically about four feet in diameter as opposed to a Yankee dryer which has a diameter of 12-22 feet and more typically 18-22 feet. The surface 40 of the dryer roll 22 will preferably be made with the outer 0.1 to 0.2 inches fabricated of a high diffusivity material, such as copper, which can significantly increase the rate of heat transfer. The web is typically moving at 3,000-6,000 feet per minute; thus the portion of the dryer roll 22 which contributes to heat transfer is only the very outer portion adjacent to the surface 40. By increasing the thermal diffusivity by using a material of higher thermal conductivity, greater heat transfer may be accomplished.

The interaction of the paper web 36 with the surface 40 of the dryer roll 22 is critical in that sufficient adherence to the roll is desirable so the paper remains attached to the roll surface until removed by the creping doctor 50. The use of flame-sprayed metal coatings can be effective in controlling the release properties of the roll's surface and such coatings may advantageously be employed to tune the roll surface to achieve the optimal properties for the functioning of the impulse dryer 20.

In addition to adjusting the surface properties of the roll by employing various roll coatings, the ramp angle between the incoming web 36 and the dryer roll 22, the position at which the forming fabric 38 leaves the surface of the roll, and the positioning of the doctor blade 50, may be adjusted as required to achieve the desired amount of drying. The relative widths of the preheat region 42, post-heating backed region 46, and the unbacked drying region 48 can be adjusted during operation of the dryer 20 to achieve the desired drying rates and formed web 37 properties. Stationary pans (not shown) are used to convey the web 37 away from the doctor and on to the sequential operations, such as calendering or reeling.

An alternative embodiment impulse dryer 60 is shown in FIG. 2. The impulse dryer 60 has a press roll 62 which is located below an enclosed extended nip press 64. The enclosed extended nip press is similar to the open-ended extended nip press 25 of FIG. 1 except that the outer grooved blanket 66 of FIG. 2 extends beyond the nip 68 and is sealed to a rotating circular cover (not shown) that prevents lubricating fluid from escaping and possibly contaminating the web 36.

The press roll 62 of FIG. 2 has a crown control support system 70 which utilizes one or more hydraulic cylinders 72 to control the shape of the roll 62. The use of a crown controlled or supported roll 62 overcomes one of the principle limitations in a tissue forming machine employing a Yankee dryer which can not be internally supported. Further with a Yankee dryer, at the present time, because of the difficulty of fabricating rolls with extended widths, tissue forming machines have typically been of lesser width than typical papermaking machines. Tissue making machines have, to this day, been limited to about 300 inches wide. The impulse dryer 60 should allow systems up to 420 inches without any great difficulty.

In the impulse dryer 60, the web 36 is transferred from the forming wire or fabric 76 to the press felt 74 by a suction pick-up roll 78 which employs a suction gland 80 to effect the transfer of the web 36. The arrangement of the extended nip press 64 above the press roll 62 is a configuration which will generally be preferred in the construction of a paper-making machine inasmuch as the web 37 travels downwardly towards the doctor blade 82 mounted on the doctor back 84. This general arrangement is preferred because it simplifies threading of the paper machine and simplifies handling of broke which is facilitated by the downward motion of the web 37 following the dryer press 60.

The web 36, 37 in transiting the dryer 60 is wrapped by the roll 78 onto the surface 86 of the roll 62 forming a preheat region 42, a pressing region 44, a post-heating backed region 46 and an unbacked drying region 48.

An induction heater 88 is located adjacent to the nip 68 and so a hood is not required. However, the induction heater 88 may be positioned further from the nip in which case the presence of a hood will advantageously prevent heat dissipation from the roll's surface 86.

Another alternative embodiment impulse dryer 90 of this invention is shown in FIG. 3. The dryer 90, similar to the dryer 60 of FIG. 2, employs a press felt 92 which carries the web 36 on it's bottom surface. The web 36 is transferred from a forming fabric 94 by a suction gland 96 as the web passes over a transfer roll 98. The press felt then passes over turning rolls 100 which

bring the press felt 92 and the web 36 into the extended nip 102 in a reverse direction so the web 36 remains longer on the hot surface 104 of the dryer roll 106. A hood 108 can be used to draw vapors away from the drying web 36. Supplemental drying by means of a high velocity air impingement hood could also be employed. The dryer 90 of FIG. 3 also employs a preheating steam box 110 similar to the steam box 58 shown in FIG. 1.

The dryer 90 thus combines the advantages of an impulse dryer formed between an extended nip press 112 and a crown-supported dryer roll 106 with an extended post-pressing drying section 114. As shown in FIG. 3 extended post-pressing drying section 114 may extend for over one hundred and eighty degrees after the nip 102 because of the dryer configuration employed. It will be understood that a post-drying section 114 of forty-five or ninety degrees can be advantageously employed. After the web has been impulse dried and dried in the extended drying section 114, a doctor 116 mounted to a doctor back 118 crepes the web 37 off the dryer surface 104.

It should be understood that the tissue impulse dryers shown in FIGS. 1-3 may have varying combinations of features. They may employ enclosed or open-ended nip press blankets. The dryer rolls may employ crown control or in shorter papermaking machines rolls with crown control may not be necessary.

A steam box may be used to preheat the web. Further, the web may be transferred to the dryer roll surface either directly from the forming wire or fabric, or the web may be transferred to a press felt before being wrapped onto the dryer roll.

It is to be understood that the advantages achieved by the impulse dryers of FIGS. 1-3 are the elimination of the necessity for a Yankee dryer with its attendant high cost and limited cross-machine length. This includes the advantage of eliminating the press rolls employed with Yankee dryers together with their attendant high cost.

It is further to be understood that the applied pressure, the amount of pre- and post-wrap of the web before and after it enters the extended nip press, and the pressure in the nip, together with the surface coating applied to

the dryer roll are variables which may be adjusted to achieve the desired result. The result desired is a web dried to approximately at least 92 percent by weight dry web which may be creped by a doctor blade from the surface of the dryer roll.

It should be understood that yet another advantage of the impulse dryers of FIGS. 1-3 is the adaptability of the dryer rolls to being periodically resurfaced by grinding and/or flame deposition of additional materials thereon. Yankee dryers require long shutdown periods to refinish the roll, resulting in significant lost revenue.

It is understood that the invention is not limited to the particular construction and arrangement of parts herein illustrated and described, but embraces such modified forms thereof as come within the scope of the following claims.

We Claim:

1. A dryer for tissue grades of paper comprising:
a dryer roll having a roll surface;
a shoe engaged with the dryer roll to form an extended nip;
a continuous vented impermeable blanket surrounding the shoe and moving through the extended nip;
a press felt means supporting a web of tissue paper thereon, the press felt means transporting the web to be dried through the extended nip, wherein the press felt means is wrapped onto the dryer roll surface upstream of the extended nip, the press felt means for preheating the web on the dryer roll prior to entering the extended nip;
an induction heater positioned to heat a portion of the dryer roll; and
a doctor blade engaged with the dryer roll surface to crepe a web of tissue paper off the dryer roll.

2. The apparatus of Claim 1 further comprising a steam box mounted upstream of the dryer roll and positioned to preheat the web before it enters the extended nip.

3. The apparatus of Claim 1 wherein the doctor blade engages the roll at least forty-five degrees downstream of the extended nip to define an extended post-pressing drying region on the dryer roll.

4. The apparatus of Claim 1 wherein the doctor blade is located at least ninety degrees downstream of the extended nip to define an extended post-drying region on the dryer roll.

5. The apparatus of Claim 1 wherein the shoe employs a closed blanket.

6. The apparatus of Claim 1 wherein the surface of the dryer roll is composed of copper which extends into the surface to a depth of between one tenth and two tenths of an inch.

7. The apparatus of Claim 1 wherein the dryer roll employs a hydraulic crown control support system.

8. The apparatus of Claim 1 wherein the induction heater is spaced more than one hundred-and-eighty degrees from the nip.

9. The apparatus of Claim 1 wherein a hood extends between the induction heater and the nip.

10. The apparatus of Claim 1 wherein a hood extends substantially between the nip and the doctor blade.

11. The apparatus of Claim 1 wherein the blanket has circumferential grooves formed therein which face the dryer roll.

12. The apparatus of Claim 1 wherein the press felt is a papermaking forming wire.

13. The apparatus of Claim 1 wherein the dryer roll is about four feet in diameter.

14. A method for forming tissue and other light grades of paper comprising the steps of:

forming a tissue web in a 12-24 percent dry range;

transporting the web on a press felt;

heating a surface of a dryer roll with an induction heater to between 300 and 700 degrees Fahrenheit;

wrapping the web backed by the press felt onto the surface of the dryer roll at a position spaced upstream from an extended nip and preheating the web on said surface;

passing the web through said extended nip while exerting a pressure of between 1,000 to 10,000 pounds per linear inch on the web;

post-heating the web on the dryer roll downstream of the extended nip while supported by the press felt;

conducting the press felt away from the web so the web remains on the surface of the roll along a region of post-heating where the web is unsupported by the felt; and

removing and creping the web from the dryer roll with a doctor blade.

15. The method of Claim 14 further comprising the step of preheating the web with a steam box mounted upstream of the dryer roll to preheat the web before it enters the extended nip.

16. The method of Claim 14 wherein the doctor is located at least forty-five degrees away from the nip to allow an extended post-pressing drying of the web on the dryer roll.

17. The method of Claim 14 wherein the doctor is located at least ninety degrees away from the nip to allow an extended post-drying region on the dryer roll.

18. The method of Claim 14 wherein the extended nip employs a closed blanket.

19. The method of Claim 14 wherein the surface of the dryer roll is composed of copper which extends into the surface to a depth of between one tenth and two tenths of an inch.

20. The method of Claim 14 wherein the dryer roll employs a hydraulic crown control support system.

21. The apparatus of Claim 14 wherein the induction heater is spaced more than one hundred eighty degrees upstream from the nip.

22. The method of Claim 14 wherein the roll passes beneath a hood after being heated and before entering the extended nip.

23. The method of Claim 14 wherein the web passes beneath a hood between the extended nip and the doctor blade.

24. The method of Claim 14 wherein the press felt and web are transported through the extended nip on a blanket which has circumferential grooves formed therein which face the dryer roll.

25. The method of Claim 14 wherein the web is formed on the press felt prior to reaching the dryer roll.

26. The method of Claim 14 wherein the dryer roll is about four feet in diameter.

27. A dryer for tissue grades of paper comprising:
a dryer roll having a roll surface;
a shoe engaged with the dryer roll to form an extended nip;
a continuous vented impermeable blanket surrounding the shoe and moving through the extended nip;
a press felt traversing the extended nip for carrying a web of tissue paper through the nip to be dried;
an induction heater positioned to heat a portion of the dryer roll;
a doctor engaged with the dryer roll surface to crepe said web of tissue paper off the dryer roll, wherein the doctor is located at least ninety degrees away from the nip to define an extended post-drying region on the dryer roll; and
a hood which extends substantially between the nip and the doctor blade.

28. The apparatus of Claim 27 wherein the surface of the dryer roll is composed of copper which extends into the surface to a depth of between one tenth and two tenths of an inch.

29. The apparatus of Claim 27 wherein the dryer roll is about four feet in diameter.

30. A dryer for tissue grades of paper comprising:
a dryer roll having a roll surface;
a shoe engaged with the dryer roll to form an extended nip;

a continuous vented impermeable blanket surrounding the shoe and moving through the extended nip;

a press felt which supports a web of tissue paper thereon, wherein the press felt extends between the dryer roll and the shoe at the extended nip;

a pre-heat-region forming roll which engages the web and the press felt upstream of the dryer roll, and wraps the web about the dryer roll to define a pre-heat region upstream of the extended nip;

an induction heater positioned to heat a portion of the dryer roll; and

a doctor blade engaged with the dryer roll surface to crepe a web of tissue paper off the dryer roll.

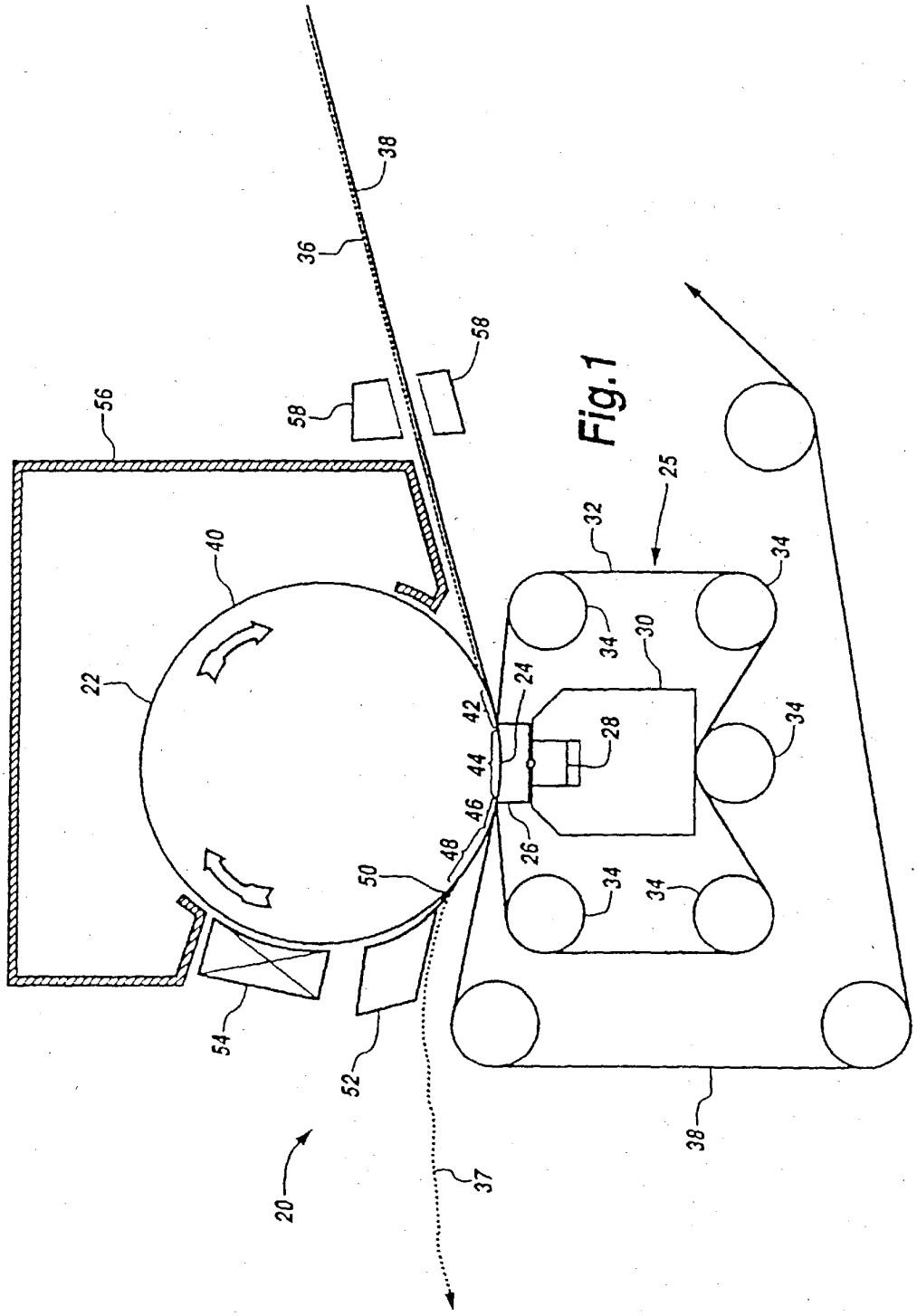

Fig.1

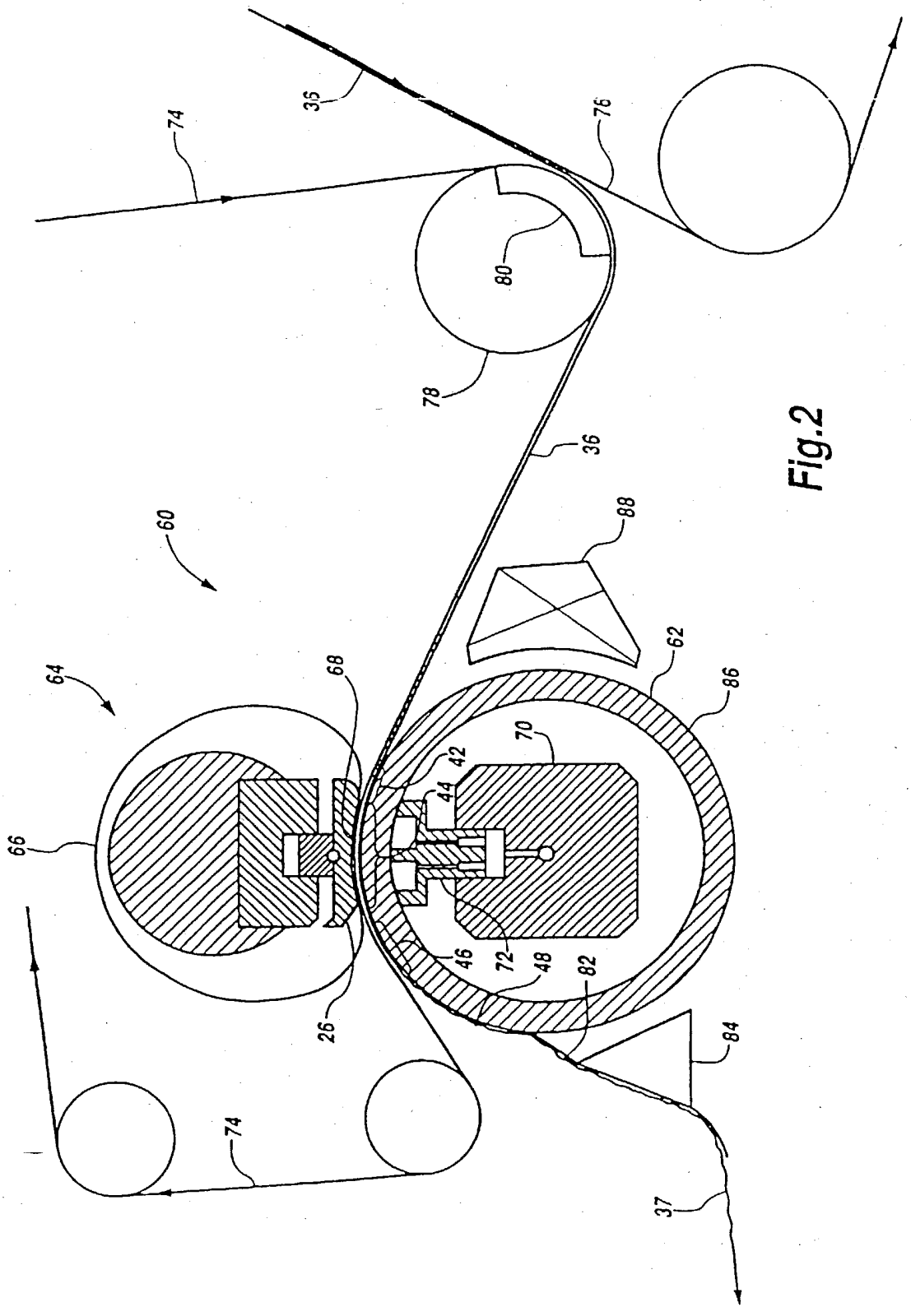

Fig.2

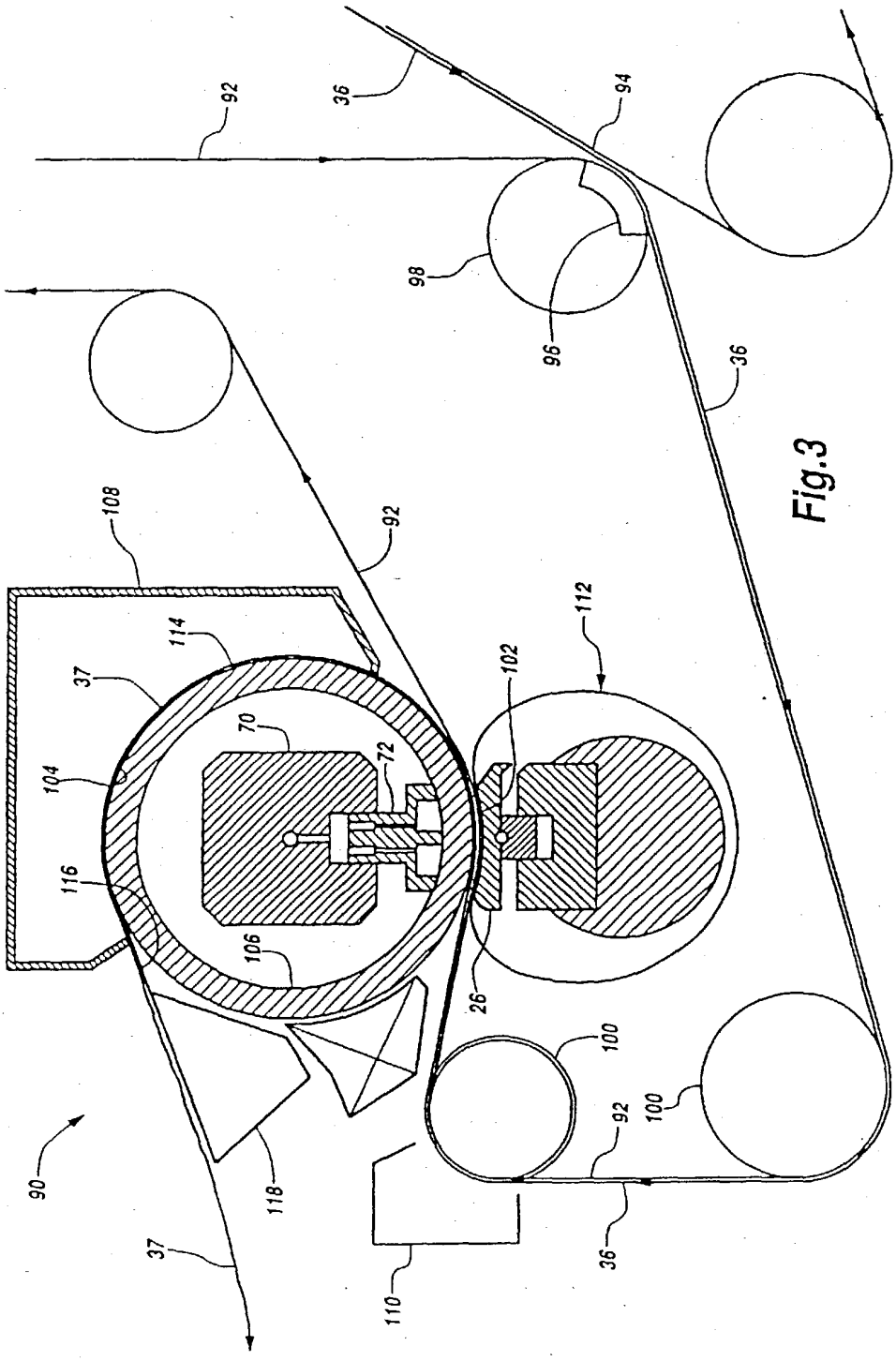
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Fig.3

INTERNATIONAL SEARCH REPORT

Int ional Application No
PCT/US 96/15022

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 D21F3/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 D21F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	EP,A,0 289 477 (VALMET PAPER MACHINERY) 2 November 1988	1-5,11, 14-18, 24,30
A	see the whole document	27

Y	WO,A,93 23613 (SULZER-ESCHER WYSS) 25 November 1993	1-5,11, 14-18, 24,30
A	see the whole document	27

A	US,A,5 439 559 (CROUSE) 8 August 1995	1,5,7, 14,20, 27,30
	see the whole document	

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

* Special categories of cited documents :

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Date of the actual completion of the international search	Date of mailing of the international search report
16 December 1996	27.12.97

Name and mailing address of the ISA	Authorized officer
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